Appl. No. 10/605,513
Amdt. dated March 17, 2005
Reply to Office action of November 17, 2004

Amendments to the Specification:

Please replace paragraph [0009] with the following amended paragraph:

[0009] In addition, the second preferred embodiment of the present invention disclosesa light emitting device (LED) comprising an n-type electrode, an n-type conductive substrate formed on the n-type electrode, a buffer layer formed on the n-type conductive substrate, an n-type contact layer formed on the buffer layer, a multiple quantum well light emitting layer formed on the n-type contact layer, a p-type cladding ~~contact~~ layer formed on the multiple quantum well light emitting layer, a p-type contact layer formed on the p-type cladding layer, a dual dopant contact layer formed on the p-type contact layer, a transparent conductive oxide layer formed on the dual dopant contact layer, and a p-type electrode formed on the transparent conductive oxide layer.

Please replace paragraph [0010] with the following amended paragraph:

[0010] It is an advantage of the present invention thata dual dopant contact layer is positioned between a transparent conductive oxide layer and the stacked semiconductor layers of the claimed LED. With the p-type dopants ~~carriers~~ and the n-type dopants ~~carriers~~ coexist in the dual dopant layer, the resistance associated with the ohmic contact between the transparent conductive oxide layer and the stacked semiconductor layers of the LED is reduced. The dual dopant layer has p-type dopants ~~carriers~~ and n-type dopants ~~carriers~~, and conductive carriers are transmitted between the transparent conductive oxide layer and p-type cladding layer for forming a good ohmic contact when the claimed LED is powered by a forward bias voltage. To sum up, the claimed LED is capable of greatly increasing intensity of the emitted light without seriously making the forward bias voltage raised.

Please replace paragraph [0015] with the following amended paragraph:

[0015] The dual dopant contact layer 24is doped by p-type impurities and n-type impurities simultaneously to form both p-type dopants ~~carriers~~ and n-type dopants ~~carriers~~ within the dual dopant contact layer 24. In the preferred embodiment, the concentration of the dopants is equal to $1*10^{19}$ cm^{-3}, and the thickness of the dual dopant contact layer 24 roughly equals 60 angstroms. As the experimental result shown in the following Table 1, the preferred embodiment has a forward bias voltage greater than a forward bias voltage required by a prior art LED utilizing a Ni/Au metallic layer, and the forward bias voltage is raised from 3.15V to 3.16V. Please note that the forward bias voltage is measured when 20mA current passes through the claimed LED10 and the prior art LED. As shown in Table 1, the preferred embodiment has light intensity greater than light intensity outputted by the prior art LED utilizing the Ni/Au metallic layer, and the light intensity is raised from 25.7mcd to 34.5mcd. That is, the light intensity is improved by 34.2%. In addition, the prior art LED with an n+ reverse tunneling contact layer is tested, and the result is shown in Table 1. It is obvious that the prior art LED wih the n+ reverse tunneling contact layer is capable of increasing the light intensity, but the required forward bias voltage is accordingly increased. Therefore, the LED10 according to the present invention can improve the light intensity without greatlyincreasing the exerted forward bias voltage. Compared with the prior art LED, the LED10 according to the present invention apparently has better performance.

Please replace paragraph [0016] with the following amended paragraph:

[0016] Please note that the formation of the dual dopant contact layer 24 is not limited by the above-mentioned manufacturing method. Takinganother LED emitting light with a wavelength equaling 526nm for example, this LED has the same structure shown in FIG. 1, but the dual dopant contact layer 24 for this LED is manufactured by another process. After the p-type contact layer 22 is fabricated, an n-type InGaN contact layer with a thickness equaling 20 angstroms is then stacked on the p-type contact layer 22. After the n-type InGaN contact layer successfully grows on the p-type contact layer 22, an

annealing process with a cooling rate less than 40°C/min is applied to make the n-type dopants within the n-type InGaN contact layer and the p-type dopants within the p-type contact layer 22 diffuse to each other. Then, the original n-type InGaN contact layer contains both n-type dopants and p-type dopants, and the InGaN contact layer becomes a dual dopant contact layer. The dual dopant contact layer then has concentration of n-type dopants ~~carriers~~ equaling $8*10^{18}$ cm^{-3}, and has concentration of p-type dopants ~~carriers~~ equaling $5*10^{18}$ cm^{-3}. The experimental result associated with the above LED is shown in Table 2.

Please replace paragraph [0018] with the following amended paragraph:

[0018] Please refer to FIG. 2, which is a structure diagram illustrating a light emitting diode 40 according to a second embodiment of the present invention. The structure of the LED 40 is similar to that of the LED 10 shown in FIG. 1. The only difference is that the compound semiconductor layers 44~56 are stacked on one side of an n-type conductive substrate 42 through an epitaxy growth, and an n-type electrode 60 contacts the n-type conductive substrate 42 on another side. Because the substrate 42 itself is conductive, it is unnecessary to perform an etch process after those compound semiconductor layers 44~56 are successfully grown on the n-type conductive substrate 42. Please note that the compound semiconductor layers 44~56 are respectively corresponding to the buffer layer 14, the n-type contact layer 16, the multiple quantum well light emitting layer 18, the p-type cladding layer 20, the p-type contact layer 22, the dual dopant contact layer 24, and the transparent conductive oxide layer 26. In Fig.2, the layers are the buffer layer 44, the n-type contact layer 46, the multiple quantum well light emitting layer 48, the p-type cladding layer 50, the p-type contact layer 52, the dual dopant contact layer 54, and the transparent conductive oxide layer 56. In addition, a p-type electrode 58 is formed on the transparent conductive oxide layer 56.

Please replace paragraph [0020] with the following amended paragraph:

[0020] In contrast to the prior art, the claimed LED positions a dual dopant layer between a transparent conductive oxide layer and the light emitting stacked structure. With the p-type ~~carriers~~ dopants and the n-type ~~carriers~~ dopants coexistent in the dual dopant layer, the resistance associated with the ohmic contact between the transparent conductive oxide layer and the light emitting stacked structure is reduced. Therefore, the claimed LED is capable of solving the problem in the prior art. Because the dual dopant layer has p-type ~~carriers~~ dopants and n-type ~~carriers~~ dopants, an energy level associated with the n-type ~~carriers~~ dopants and an energy level associated with the p-type ~~carriers~~ dopants are located within the energy band gap of the dual dopant layer. Therefore, when the claimed LED is powered by a forward bias voltage, carriers are conductive through both coexisted energy levels. Therefore, conductive carriers are transmitted between the transparent conductive oxide layer and p-type cladding layer for forming a good ohmic contact between the transparent conductive oxide layer and the stacked semiconductor layers of the LED. With this transmission mechanism, it is unnecessary to fabricate a prior art highly doped p-type contact layer. Therefore, the problem related to forming the prior art highly doped p-type contact layer is solved by the claimed LED. In addition, the claimed LED is capable of greatly increasing intensity of the emitted light without seriously raising forward bias voltage. To sum up, the overall performance of the claimed LED is better than the performance of the prior art LED.